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A Geologist on Capitol Hill

Carroll Ann Hodges

As the unpredicted and unpredictable 97th Congress convenes, I would like to report on my experience thus far as the 1980–1981 American Geophysical Union Congressional Science Fellow. The past 4 months have been exhilarating, and, as one who has never had the slightest contact with political science, I have found this opportunity for a glimpse of the Washington 'corridors of power' an incredible education. I spent the last 10 years in planetary geology with the U.S. Geological Survey. Before that I worked for both oil and mining companies and taught in a couple of universities. Having also been active in community affairs, I was intrigued by the opportunity to see firsthand how congressional policies dealing with energy, environment, minerals, and land use are developed. Breadth of interest is an asset in approaching this sort of experience.

I hope a brief summary of my impressions may entice others in the earth science community to explore the possibility of lending time and talents in exchange for a unique experience in our capital.

The American Association for the Advancement of Science (AAAS) arranged a superb orientation program for this year's class of 38 fellows who come from academia, government, industry, or fresh from graduate school. About half of the fellows are social scientists (anthropologists, historians, philosophers, psychologists), and the other half are physical scientists, such as biologists, physicists, chemists, engineers, and one geologist (me).

During orientation, in the first 2 weeks of September, we were accorded special briefings from the State Department, Pentagon, Library of Congress, National Academy of Sciences, then Presidential Science Advisor Frank Press and staff, Office of Technology Assessment, General Accounting Office, and Management and Budget. In addition, we had numerous sessions with former fellows who now have permanent staff positions with individual congressmen or committees. It was an exciting time, perhaps highlighted by a luncheon in the Senate dining room and by remarks from Senators John Glenn, Paul Tsongas, Charles Mathias, and Strom Thurmond.

Following this, and armed with AAAS guidelines and some sanguine advice from former fellows, each of us faced the task of seeking desk space in the office of a senator, representative, or one of the committee staffs. Admittedly, as fellows we had a distinct advantage in that we were looking for work as free bodies, funded by our sponsoring organizations. Nevertheless, one still had to overcome the very serious problem of space. Many offices simply had no room. Another difficulty was caused by the uncertainty of the 1980 elections. Numerous senators and representatives were unwilling to take on additional staff, given their election prospects. Then there was the matter of vested interests: Most offices have the necessary legislative areas covered already by a legislative assistant, and many of them are 'protective of their respective turfs' (a buzz phrase quickly learned!). Some offices, despite the efforts of AAAS to explain our program, simply were unaware of the existence of science fellows. Persistence and fortitude were the key, but exalted views of one's status and credentials were rather unceremoniously squelched.

Clearly, the objective was to find an office which had interests compatible with one's professional background, and the legislative priorities of congressmen are best inferred by their committee affiliations. Most of us, I suspect, were unaware of the enormous importance of committees and subcommittees, which indeed determine legislation. 'Congress is a collection of committees that come together in a chamber periodically to approve one another's actions' (Clem Miller, in *Member of the House*, 1962). As a geologist, I limited my interviews to those committees or congressmen with jurisdictions in areas such as energy or environment. I was most anxious to investigate all the available options before committing myself, and in so doing I followed the example of my AGU predecessor Bob Barbera, who subsequently chalked up such a dynamite record that he is now a permanent staffer with Senator Paul Tsongas. I eventually interviewed in about 40 offices. I am now on the staff of Congressman Jim Santini of Nevada. Perhaps it is appropriate to review the route by which I got here.

I began my quest for desk space with the House Science and Technology Subcommittee staffs, which include a number of former fellows. Gaining entrée there was easy. The same was true with various Senate committees. Committees are fewer in the Senate (15, as opposed to 23 in the House), with better defined jurisdictions and less obvious overlap. (I concluded that virtually every subcommittee in the House had its finger in the energy pie one way or another—explaining in part why policy is so long in forthcoming!) The most obvious advantages of committee affiliation, in contrast to a member's office, are the limited focus of legislative issues, the luxury of having time to research an issue in some depth, the chance to participate in floor action, and the lack of distractions like constituent mail response or sometimes inconsequential chores. Despite interests in many committee jurisdictions, however, I ultimately decided that the purview of a single subcommittee would not offer the breadth of opportunity to participate fully in the legislative process that I was seeking for my 1 year in Washington, and further, that the committee scene was a bit removed and insulated from the congressional scene. I opted for a wider range of experiences, and therefore I searched for a congressman with committee leadership in an area of interest to me.

An additional factor in my choosing process was geography of the state or district represented. A Californian at present, I checked out a number of that state's delegation, partly because of the state's large assortment of geologically related concerns and partly because I felt most attuned to the special interests of my own state. Failing affiliation with California, I was inclined to think my enthusiasm for parochial matters would be greatest within delegations from the western states.

Having invaded offices of both senators and representatives, I might describe some perceived differences between the two sides of the Hill. First of all, there are only 100 egos to accommodate in the Senate, as opposed to 435 in the House, so that generally speaking the Senate seems more organized and orderly, not to mention elite. Of course, running for reelection every 2 years imposes a considerable burden on House members, and the pace seems notably more frenetic. But Senate staffs are much larger (having to serve more constituents) than are House staffs, and it appears that senators were likely to be less accessible to staff than representatives. Congressional staffs are surprisingly large, having proliferated considerably in the last 10 years—a trend recently lamented in the *Washington Post* as 'staffiation.'

The interview process was indeed exhausting—but undeniably stimulating and challenging. Staff time is precious, so one has to be organized to exchange essential information quickly (with a one page only resumé) and try for a return engagement in those offices that seem especially promising. One must inquire about probable assignments, space (a gigantic problem, especially in the House), special interests of the congressman, and his/her probable accessibility. It's helpful to know what kinds of legislation he/she has sponsored, how successfully, and what other staffs have to say about his/her office. Also, political philosophy is likely to enter into most placement decisions, so voting records on key issues are useful to have at hand; it's the congressman who has been elected, so a fellow's political inclinations must be 'torqued' accordingly. Most important is the general ambience of the office; tension clearly pervades some staffs, and quarters are so tight that personality conflicts could make life unnecessarily difficult. Furthermore, in my case it was essential to find out the amount and calibre of typing required. A number of offices have no clerical help, so fellows and everyone else have to do final typing for a congressman's signature—an untenable set-up for me!

My long odyssey finally ended in the office of Congressman Santini, the only representative from Nevada. His Legislative Director was not only cordial, relaxed, good humored, and competent, but also totally unpretentious—a quality I've found rather rare on Capitol Hill. Santini's chairmanship of the Interior Subcommittee on Mines and Mining has been illustrious; he has become a well-known, effective, and respected spokesman for the minerals industry and is an advocate of a national minerals policy, an issue in which I have long been interested. Santini also serves on the Public Lands Subcommittee, has been actively involved in an effort to save Lake Tahoe from environmental deterioration, has wrestled with the problem of nuclear waste disposal, and is vitally concerned about the potential impact of the Air Force MX missile deployment across vast portions of Nevada public lands. My geological background meshed with the needs of the office, and the staff seemed exceptionally congenial, and so I finally committed my peripatetic feet to a desk, phone, and, yes, a typewriter (after ensuring I would not be required to do final typing). The office isn't luxurious (none are), but the 'chemistry' seems right. Thus far I've answered some constituent mail regarding issues of interest to me (including the fate of wild horses), have delved into the Environmental Impact Statement prepared for the Air Force on its MX project, and am catching up on the minerals policy issue. I've acquired names and phone numbers and information from impressively knowledgeable people on specified topics, and have concluded the 'name of the game' is knowing whom to call.

Probably the greatest frustration in this experience is the necessity of doing most assignments quickly. One collects superficial knowledge on a wide array of topics, and tunnel vision just won't wash. The information resources of the Congress are extraordinary, particularly the Congressional Research Service which issues and updates timely briefs on 'hot' legislative topics (like the MX or nuclear waste disposal); the services provided by this arm of the Library of Congress are outstanding. In addition, congressmen can call on the Office of Technology Assessment, General Accounting Office, and Congressional Budget Office for the in-depth analyses which an individual's staff has neither the time nor expertise to carry out. 'Network' is another of those buzz words a newcomer quickly learns, but the importance of 'plugging in' cannot be overemphasized; every casual contact is a potential source of critical information. Fellows and former fellows are a vital part of the network, and AAAS does a great job of facilitating continued contact through a series of seminar programs during the year at which distinguished speakers share views on relevant topics. Perhaps most important are one's professional colleagues and acquaintances, including former professors.

Carroll Ann Hodges, AGU's 1980–1981 Congressional Science Fellow, is on leave from the U.S.G.S. in Menlo Park, California.

A fact quickly learned is that political realities color every decision and vote; in the House at least, reelection is never on the back burner. And shepherding legislation through the Congress is but one of countless demands on a congressman's time and staff. To be effective, a congressman must pick and choose his/her issues carefully, become expert on a very few, and rely on staff and colleague advice for most votes he/she casts. So a fellow cannot assume he/she automatically has a pipeline for a long cherished proposal (a Nevada congressman is not likely to squander effort on a recycling bill, for example). Still, every bill starts with an idea, and Congress is eager for good ones, the magic component of which is generally compromise.

One perceives that there is indeed a paucity of staff people with scientific credentials, yet the numbers of legislative issues that require scientific and technological analyses are increasing with every Congress. Staffs do a remarkable job of keeping on top of such issues, however, and I think most of us would acknowledge with admiration the thousands of talented, articulate, dedicated, highly motivated, and mostly young men and women who grease the wheels of the federal machinery. Thanks to the efforts of AAAS and member organizations like AGU which support the Science Fellow program, technical and scientific personnel are gradually infiltrating the system. For one with an interest in civic affairs and anxious for career direction, or change of direction, or simply enlarged horizons—and having a tolerance for cold winters and hot summers—this is surely a most splendid opportunity. For me, it was a chance to clear away the cobwebs from a beclouded mind that had been pursuing the planets for 10 years, and now I shall certainly have a different perspective on the news that pours forth daily from 'our nation's capital.'

Having explored what seemed to me to be all the available options on the Hill, I am delighted with the association I've established for the year and look forward enthusiastically to plunging into the legislative foray. I might add that the procedure I followed for gaining entry into as many offices as possible that seemed potentially promising was arduous, and sometimes discouraging, but ultimately rewarding. It was essential to me that interaction with staff be informal, and that the congressman be one whose political views I could respect if not consistently agree with. Work assignments are generally so far removed from anything one has ever done before that it is bound to be a stimulating experience, regardless of the name on the office door. The major challenge is forging a modus operandi that enables one to be effective in this role of uniquely privileged bit player on such an awesome stage.

AGU Congressional Science Fellowship

The individual selected will spend a year on the staff of a congressional committee or a House or Senate member, advising on a wide range of scientific issues as they pertain to public policy questions.

Prospective applicants should have a broad background in science, be articulate, literate, flexible, and able to work well with people from diverse professional backgrounds. Prior experience in public policy is not necessary, although such experience and/or a demonstrable interest in applying science to the solution of public problems is desirable.

The fellowship carries with it a stipend of up to $25,000 plus travel allowances.

Interested candidates should submit a letter of intent, a curriculum vitae, and three letters of recommendation to AGU. For further details, write Member Programs Division, Congressional Fellowship Program, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

Deadline: March 31, 1981.

News

Reagan's Budget Slashes Geophysics R&D

When President Ronald Reagan outlined to a joint session of Congress his proposed revisions to the Carter fiscal 1982 budget (*Eos*, February 10, p. 49), Congress responded with 13 bursts of applause and one standing ovation. Geophysicists, however, may not greet the budget pruning with equal fanfare. Reagan's across-the-board cuts include proposals for slashing research and development funds. Among those hardest hit are NASA, NOAA, and NSF.

The preliminary Reagan budget document, *America's New Beginning: A Program for Economic Recovery*, outlines the proposed cuts, but dollar-by-dollar analyses have yet to be posted. Details of funding for individual programs will be released next week with the publication of the complete budget. *Eos* will monitor those changes that will affect geophysicists.

Despite the enthusiasm shown by Congress during Reagan's February 18 speech, the acid test of Capitol Hill opinion on the revised budget will come when work begins on budget approval. According to a report in the *Washington Post* on the morning following the speech, Reagan aides believe that chances for approval are best if the budget is considered quickly and as a total package.

NASA's GRO and VOIR Deferred

Jimmy Carter allocated a 21% increase over the fiscal 1981 budget for NASA in fiscal 1982. 'This sharp increase is incompatible with a program of across-the-board restraint,' Reagan reasoned. He therefore proposes to whittle the increase to about 12%, giving the agency real growth of 2% with a 10% inflation rate. NASA is now budgeted for $6.235 billion in fiscal 1982, a decrease of $330 million from the Carter budget.

The space shuttle program probably will be maintained, but the Gamma Ray Observatory, the Venus Orbiting Imaging Radar, and the Spacelab experiments will be deferred for an unspecified period, according to the Reagan budget document. A NASA scientist said that VOIR will not be deferred but will continue as an item in the budget, however, development will be slower than envisioned by Carter. Full support will continue for the development of the space telescope at the Johns Hopkins University (*Eos*, February 10, p. 50). Funding for the solar electric propulsion system will be eliminated, and space science flight projects will be rescheduled.

Support is provided in Reagan's budget to 'fully utilize spacecraft launched in prior years that are still transmitting useful data;' Voyager spacecraft fall into this category. The Galileo mission to Jupiter will be maintained as part of 'an orderly progression in the exploration of the planets.' United States' participation in the international solar polar mission will continue, but more slowly than Carter had envisioned.

Funds for remote sensing will be cut, as will those for research on weather and climate and those for research on the advanced communications technology needed to increase the useful range of radio frequencies.

NSF Lab Modernization Postponed

Reagan plans to 'selectively reduce or eliminate' some NSF programs, but he will maintain 'ongoing support for its critical responsibilities in the advancement of science.' Proposed for reduction or elimination are programs deemed of 'less immediate priority' or 'less critical to meeting the goals and objectives' of NSF.

Slated for deferment are all new programs proposed in the Carter 1982 budget for NSF, including the $75-million program to modernize university laboratories and the program to build the 25-m, millimeter wave telescope in Hawaii. Funds allocated by Carter for basic and applied research in the division of astronomical, atmospheric, earth, and ocean sciences will be maintained, however.

No mention was made of the ocean margin drilling programs. Exact funding for specific programs will be announced next week.

NOAA Closely Shaved

Government funds for NOAA will be reduced from Carter's $184 million allocation for fiscal 1982 to $32 million. Money for the Coastal Energy Impact Program and the Coastal Zone Management Program will be terminated under Reagan's Economic Recovery Program. Federal assistance to sea grant colleges for marine research will be halved. In addition, the National Oceanic Satellite System (NOSS) will be deferred.

'States and localities should assume responsibility for those NOAA programs from which they directly benefit,' Reagan said. He estimated that NOAA program costs can be reduced by more than $1 billion over the next 5 years. 'These changes are consistent with the original intent of the coastal programs—to provide Federal assistance only when essential and for front-end seed money,' he continued.

Most of the $1 billion reduction of federal funds can be attributed to the deferment of NOSS. Reagan estimated that the government will save $900 million over the next 7 years with the postponement. Reagan explained the rationale for the delay: 'The cost of NOSS is too high at this time and oceanographic data needs can be met through other means.'

USGS Cuts Not Outlined

Reductions, if any, in the USGS fiscal 1982 budget were not delineated in the Reagan preliminary document. Cutbacks for the Department of the Interior were included, but department officials have yet to hammer out the agency breakdowns.—*BTS*

Quake Station in China

The United States installed the first permanent seismological station in the People's Republic of China late last year. Located in the city of Kunming, in southern China, the station is part of the International Deployment of Accelerators (IDA) program, a network of 17 seismometers in 15 countries.

The monitoring equipment, installed by scientists from the University of California's Institute of Geophysics and Planetary Physics at Scripps Institution of Oceanography, measures long-period earth movements that result from major earthquakes. Information collected by cassette recording tapes is analyzed by computers in San Diego and is combined with data from other stations worldwide.

The Petroleum Exponential (Again)

The U.S. production and reserves of liquid and gaseous petroleum have declined since 1950, at least in the lower 48 states. This decline stems from decreased discovery rates, as predicted by M. King Hubbert in the mid-1950's. Hubbert's once unpopular views were based on statistical analysis of the production history of the petroleum industry, and now, even with inclusion of the statistical perturbation caused by the Prudhoe Bay-North Alaskan Slope discovery (the largest oil field ever found in the United States), it seems clear again that production is following the exponential curve to depletion of the resource—to the end of the ultimate yield of petroleum from wells in the United States.

In a recent report, C. Hall and C. Cleveland of Cornell University show that large atypical discoveries, such as the Prudhoe Bay find, are but minor influences on what now appears to be the crucial intersection of two exponentials [*Science, 211*, 576–579, 1981]: the production-per-drilled-foot curve of Hubbert, which crosses zero production no later than the year 2005; the other, a curve that plots the energy cost of drilling and extraction with time; that is, the cost-time rate of how much oil is used to drill and extract oil from the ground. The intersection, if no other discoveries the size of the Prudhoe Bay field are made, could be as early as 1990, the end of the present decade. The inclusion of each Prudhoe-Bay-size find extends the year of intersection by only about 6 years. Beyond that point, more than one barrel of petroleum would be expended for each barrel extracted from the ground. The oil exploration-extraction and refining industry is currently the second most energy intensive industry in the U.S., and the message seems clear. Either more efficient drilling and production techniques are discovered, or domestic production will cease well before the end of this century if the Hubbert analysis modified by Hall and Cleveland is correct.

A close look at the method by which the projected intersection of exponentials was deduced reveals that the crucial exponential is still 'barrels per foot drilled' production curve. Hubbert's extrapolation was formulated from petroleum industry trends dating back to the 1930's. Then, some 250 barrels of oil were recovered per foot, compared with about 6–25 barrels per foot today. It should also be noted that most domestic oil being produced today comes from fields that were discovered before 1940. In 1977, it cost a quantity of energy equivalent to approximately 1.5 barrels of petroleum for each foot drilled, up from a small fraction of a barrel in 1950, and thus the time when the U.S. actually stops producing oil may not be when the wells run dry. The time may be sooner by 10–25 years, when the production of petroleum will no longer be a net process, i.e., the energy cost will be the same as the value of the energy recovered (see figure).

The curves for 'barrels-per-foot-drilled' appear to be very sensitive to the rates of drilling. At high rates the yield per drilled foot is about 300% lower than at low rates. Combination of the many factors that enter into this analysis, however, could conceal the causes. For example, federal taxation policy can strongly influence the profits taken for oil discovery. Likewise, a large portion of the drilling footage may not be for the search of new discoveries. Most drilling is done in known fields to extend the yield, as economics permit.

If one views the exponentials as simply as a 'number cruncher' would, one might conclude (as did Hall and Cleveland) that 'the current trend of increasing conventional effort by the oil industry may not be in the best interest of the nation . . .' [op. cit.]. This conclusion is an obvious one based on the trend to lower efficiency at the higher rates of drilling. Instead, one is reminded of the extraction rates of other industries in the field of natural resources. The mining and metals industry has traditionally been able to improve its extraction efficiency as concentrations of metals in ores have decreased from several percent to a few tenths of a percent. What has been apparent in the mining and other extraction industries is that the product per ton rate diminishes but that the efficiency of extraction per ton increases. Just as it has always been that extensive lower grade ore deposits are more economic than lesser extents of more concentrated ores, the rule has been that the lower grade ores last longer, much longer. Improved extraction is the key.

As in the mining industry, the yield of barrels per foot drilled may level off, as the 'grade' of petroleum deposits decreases. If petroleum is replaced by solid fuel (coal) in industry and in power generation, not only will the petroleum cost of drilling and extracting go down (possibly to zero), but the need for new discoveries will be less desperate. Rumors of huge petroleum deposits centered in Wyoming, planned extensions of new fields off Alaska (although the last 200 wells drilled in Prudhoe Bay were dry), and discovery of new potential oil fields under the Appalachian and along the continental margins can only add to the extensive but lower grade (or higher cost) fields. It appears therefore, that the levelling off of the function (now difficult to predict) that describes the demand for petroleum versus the supply is the key intangible.—*PMB*

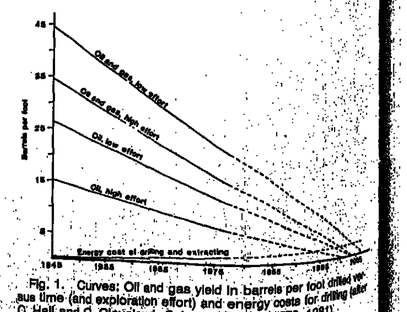

Fig. 1. Curves: Oil and gas yield in barrels per foot drilled versus time (and exploration effort) and energy costs for drilling (after C. Hall and C. Cleveland, *Science, 211*, 576–579, 1981).

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Cover. Four stages during an experimental simulation of meteor impact into a multilayered planetary surface. Part of a series of experiments conducted by R. Greeley and J. H. Fink of Arizona State University and D. E. Gault of the Murphys Center for Planetology (Murphys, California) at NASA Ames Vertical Gun Facility, July, 1980. The photos were taken manually with two Polaroid cameras mounted outside the target chamber. (Top left) Target prior to impact. Target consists of one-half inch thick surface layer of sand weakly bonded with epoxy (tensile strength of layer ≃ 10^7 dynes/cm^2) overlying clay-water slurry (yield strength ≃ 50 dyne/cm^2; plastic viscosity ≃ 200 poises). Cylindrical bucket is 1 ft deep and has a 3 ft diameter. (Top right) 0.2 s after impact of one-quarter inch pyrex sphere fired at 1.84 km/s. The crust fractures and fragments into steep ejecta plume as initial crater bowl expands below surface. (Bottom left) Oscillating central mound begins to collapse, sending out a 3 cm high surge wave of substrate material. (Bottom right) Final morphology. Note circumferential and radial fractures.

Forum

Source of Digital Terrain Data

The digital terrain map of the United States published on the cover of *Eos*, v. 62, no. 1, January 6, 1981, has stirred a number of enquiries about enlarged copies and the data source. The terrain data are available from:

U.S. Department of Commerce
NOAA/EDIS/NGSDC (D62)
325 Broadway
Boulder, CO 80303

A color terrain map by R. H. Godson of the U.S. Geological Survey, at an approximate scale of 1:7,500,000, is in press as *Miscellaneous Investigations Map I-1318* (limited release in late spring). Godson should have been listed as a co-contributor of the image used by *Eos*.

Martin F. Kane
U.S. Geological Survey

New Publications

Dynamics of the Magnetosphere

S.-I. Akasofu (Ed.), D. Reidel, Hingham, Massachusetts, xi + 658 pp., 1980.

Reviewed by A. Nishida

Earth's magnetosphere is a huge energy converter floating in the solar system. It absorbs energy from the solar wind in the earth's neighborhood in highly ingenious ways and creates a variety of phenomena, among which are the aurora, natural radio waves, and trapped radiation. Human understanding of the nature of this energy converter has advanced tremendously owing to the advent of spacecraft which has made the in situ observations of the key factors possible, and there is a widely shared feeling in the community that the investigation of our magnetosphere will contribute to the understanding of the cosmic phenomena in general by establishing elementary characteristics of space plasmas on experimental bases.

This volume is an outcome of a 1-week symposium that was held at Los Alamos Scientific Laboratory on October 9–13, 1978, and it provides a comprehensive overview of the current state of development of the magnetospheric research. From observations and theoretical efforts in the past, one mechanism has emerged as a key process—reconnection of magnetic field lines. This mechanism has been invoked both for entry of the solar-wind energy into the magnetosphere and for sudden outbreak of particle accelerations within the magnetosphere. At the same time this mechanism has never failed to have sound criticisms, and in this sense it has played a role of a highly stimulating guiding hypothesis. We can see that the concept of reconnection is either discussed explicitly or serves as an undertone in most of the papers contained in the volume.

The volume has 32 papers, and it is divided into six chapters. Chapter 1, 'Interplanetary Magnetic Field and the Magnetosphere,' deals with entry of the solar-wind energy into the magnetosphere. The fact that the chapter on the energy supply has 'interplanetary magnetic field' within the title clearly demonstrates the status of the reconnection hypothesis in the field. Four papers review observational evidences which testify to the dependence of the magnetospheric conditions on the interplanetary magnetic field, and N. U. Crooker presents her most recent model of the topology of reconnected field lines on the dayside of the magnetosphere. A lucid theoretical account of transport mechanisms at the magnetopause is given by B. U. Ö. Sonnerup. But the dayside reconnection is not short of critics. S. Mende et al. report an analysis, based on observations of the dayside aurora, which claims that lowering in latitude of the dayside cusp cannot be taken as an unquestionable evidence of the dayside reconnection as has formerly been suggested.

Chapter 2, 'Magnetosphere-Ionosphere Coupling,' deals with the final destination of the supplied energy. Emphasis is on the large-scale electric current system produced three-dimensionally from the magnetosphere to the ionosphere. While the gross structure of this current system has been deduced from spacecraft observations, the ground-based radar system has played a powerful role in delineating its fine structures and temporal developments. R. A. Greenwald provides us with comprehensive information on the latter subject starting from the basic theory.

Chapter 3, 'Plasma Processes in the Magnetosphere,' contains theoretical papers only. Theoretical papers are scattered throughout other chapters, too, and I cannot find a clear distinction between the papers in this chapter and the theoretical papers given elsewhere, particularly in chapter 5. Subjects discussed are plasma microinstabilities in relation to reconnection, overall dynamics and energetics of magnetospheric substorms, and magnetic pulsations associated with substorms. K. Papadopoulous presents a convenient summary of frequencies, growth rates, and excitation conditions for several modes of plasma waves which may be important in the magnetotail.

Chapter 4 is entitled 'Ring Current Formation.' The ring current that flows around the earth is carried by energetic particles trapped in the geomagnetic field, and its growth reflects injection of energy into the radiation belt. The energy is most certainly supplied by the solar wind, but the particles that constitute the radiation belt are not entirely from the solar wind. D. J. Williams reviews observational evidences, obtained from ion composition measurements, that suggest injection of the accelerated ionospheric ions into the radiation belt. It is unfortunate that complementary observations on electrons are not available in this volume. Physics of the field-aligned electric field is not discussed very extensively, either, while its importance is emphasized repeatedly.

The topics in chapter 5, 'Substorm Mechanisms,' range from a crude outline of the overall mechanism to detailed mathematical or numerical presentation of some specific mechanism. G. Atkinson in the first half of his paper gives a concise and clear presentation on the basic processes that govern energy flow from the solar wind to the magnetosphere. A. Hasegawa and T. Sato present a beautiful mathematical formulation of linkage between the magnetospheric current and the field-aligned current. S.-I. Akasofu advocates that the substorm is driven directly by energy supply from the solar wind rather than by unloading of the energy stored inside the magnetosphere. He also advocates a 'current interruption model' in which the interrupted cross-tail current is diverted toward the earth. Doesn't interruption of the cross-tail current mean unloading of the magnetic field energy of the tail?

Chapter 6 is entitled 'Substorm Processes in the Magnetotail,' and here reconnection in the magnetotail is the central issue. The spell of reconnection is so great that every tailward flow of plasma and every southward polarity of magnetic field appear to be compared with expectation from the reconnection model; every case which does not comply with the expectations is announced as a fatal blow to the idea. Apparently, reconnection cannot explain everything, but it is also true that the cases presented by E. W. Hones are compatible with the reconnection model but not with another proposed model (rarefaction wave model). It is my impression that there are multitudes of driving mechanisms for the magnetotail dynamics.

A great majority of the papers contained in this volume are well written and self-contained; the volume is free from the flaw, often encountered in conference proceedings, of carrying fragmentary pieces of work. Owing to space limitations, unfortunately only a small fraction of the good papers could be cited. Where there is conflict in views, both parties are well represented. Clear theoretical articles, such as those quoted above, augment the value of the book.

Water Quality Tested in Kentucky Coalfields

The Kentucky Geological Survey received a $1.1 million grant to collect information on groundwater quality and quantity in the eastern Kentucky coalfields. The funding extends a 1-year, $211,000 grant from the U.S. Geological Survey.

Water will be sampled continuously from between 40 and 50 core holes or wells, each drilled to an average depth of 120 meters. Quality and levels of the water are the main concern of the monitoring. By using standard submersible pumps, researchers will also be able to test each well's potential to supply water to industry and municipalities, according to Jon Kiefer, project coordinator.

Impetus for the project is the Surface Mine and Reclamation Act of 1977, which requires assessments of surface water and groundwater before a mining permit is issued. In addition, water conditions that may change during or after mining must be outlined.

A final report is expected to be published in January 1985.

1980 Weather Summary

The weather in the United States during 1980 was bad. A 3-month heat wave in the southwest caused about $20 billion in ruined crops, an increase in power consumption, and damage to roads and highways. Nationwide, the heat killed 1320 people. Floods caused more than $1 billion in losses. Hurricane Allen caused about $500 million in property losses and took two lives.

The highest temperature reading during 1980, 51° C (124° F), was reached five times. Locations were at Bull Head, Arizona; Death Valley, California; and three times at Baker, California. Preliminary figures also show that the lowest temperature for the year was recorded at Tok weather station, 150 miles southeast of Fairbanks, Alaska. There the mercury plummeted to −56° C (−68° F). In the lower 48 states the minimum thermometer reading was −44° C at Wisdom, Montana.

Deaths caused by lightning were down to 78 last year from the 20-year average of 104. Deaths caused by tornadoes dropped to 28, the second lowest total in 65 years. Lightning storms also produced more than $750 million in damage.

The following is a summary of the extraordinarily bad weather:

Spring flooding began in March in Alabama and Mississippi with rainfalls of 18 inches, more than three times normal. Also in March, Mt. St. Helens erupted. Although not of itself a weather event, the huge plumes of ash and gases affected the weather. The eruption left 34 dead and caused more than $150 million damage.

On April 27 heavy thunderstorms and wind gusts of up to 42 mph contributed to conditions that caused a ship to crash into Sunshine Skyline Bridge at Tampa Bay. Thirty lives were lost, and harbor traffic was delayed for 5 days.

The great summer heat wave—between June and mid-August—was the United States' most devastating weather calamity during 1980. On July 13, temperature records were shattered in several southern states. Dallas, Texas, had 38° C (100° F), or above, each day from June 23 to August 3.

The corn, cotton, peanut, and spring wheat crops were particularly hard hit by the heat. The Consumer Price Index for food and beverages, which had risen only one third as much as the rest of the index during the first half of 1980, jumped twice as much during the second half.

Of the named 11 tropical storms, only one, Hurricane Allen, struck the U.S. mainland.

Autumn brought smog and heat to the Los Angeles basin from September 29 to October 11. This produced 'hazardous' pollution levels for 3 days and temperatures averaging above normal.

The year ended with floods in the Pacific Northwest, where a 2- to 5-inch rainstorm December 26–28 hit parts of Washington and Oregon. [Source: NOAA]—*PMB*

Seismic Reflection Data Available

High-resolution seismic reflection data are now available for the area offshore the southeast Georgia embayment associated with Outer Continental Shelf (OCS) lease sale 56.

Approximately 6400 km of high-resolution data were gathered from 286 tracts that covered 1,625,251 million acres in water depths from 14 m to 2025 m. These data were gathered to help evaluate the geological hazards related to oil and gas development in the area.

Data were collected and interpreted by Fairfield Industries, Inc., under contract to the U.S. Geological Survey. USGS provided the data to the National Geophysical and Solar-Terrestrial Data Center for public distribution.

For additional information, contact the National Oceanic and Atmospheric Administration, EDIS/NGSDC Code D621, 325 Broadway, Boulder, Colorado 80303, or call (303) 497-6338.

Science Policy Fellowships

To encourage scientists to contribute to public policy issues that involve the natural sciences, the Brookings Institution in Washington, D.C., has established a Science Policy Fellowship program, slated to begin with the 1981–1982 academic year. The program will bring senior scientists to Washington for 1 year to work with the Brookings staff on science policy issues.

Fellowships will be awarded annually to three scientists from among candidates nominated by an advisory committee, by departments of natural science at universities and private research institutions, and by the public sector. The new program is supported by a 3-year grant from the Sloan Foundation.

For additional information about the fellowships, contact Jim Farrell, The Brookings Institution, 1775 Massachusetts Avenue, N.W., Washington, D.C. 20036 (telephone: 202/797-6220).

Field Research Proposals

The Center for Field Research is seeking proposals from postdoctoral scholars in need of funding, and they are also seeking volunteers for field work. The center relies on volunteers from Earthwatch, a national volunteer program. These volunteers provide the finances to cover all their own field costs and a designated share of project expenses. Total annual awards from the center exceed $600,000.

Research must be able to use teams of volunteers in the field to qualify for support. Dissertation and undergraduate research are not currently eligible; however, inclusion of graduate students as staff is encouraged. There are no limits on the geographic location of projects.

To apply, submit a two-page preliminary proposal that outlines objectives, project dates, and the need for funds and volunteers. Upon favorable review, the center will invite the applicant to prepare a formal proposal. Preliminary proposals have no deadline, but formal ones are due April 1 and October 1 and must precede the field work by 9 months.

For additional information on application procedures and a listing of projects that received support in 1980, contact Patti A. Prunhuber, Project Manager, The Center for Field Research, 10 Juniper Road, Box 127-N, Belmont, Massachusetts 02178 (telephone: 617/489-3032).

This volume represents a landmark in the understanding of magnetospheric physics, and future advances will be measured from here.

A. Nishida is with the Institute of Space and Aeronautical Science, University of Tokyo.

New Listings

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Geysers and Geothermal Energy, J. S. Rinehart, Springer, New York, xvi + 223 pp., 1980, $19.80.

Introduction to Communication Science and Systems, Applications of Communications Theory, J. R. Pierce and E. C. Posner, Plenum, New York, xvi + 390 pp., 1980, $27.50.

Metamorphic Petrology, Mineralogical, Field, and Tectonic Aspects, Second Edition, F. J. Turner, McGraw-Hill, New York, xv + 524 pp., 1981, $28.50.

Nickel in the Environment, J. O. Nriagu (Ed.), John Wiley, New York, xl + 833 pp., 1980.

Optical Mineralogy, The Nonopaque Minerals, W. R. Phillips, D. T. Griffen, W. H. Freeman, San Francisco, Calif., xl + 677 pp., 1980, $39.95.

The Paleobiology of Plant Protists, H. Tappan, W. H. Freeman, San Francisco, Calif., xxl + 1028 pp., 1980, $95.00.

Physical Applications of Stationary Time-Series, E. A. Robinson, Macmillan, New York, xl + 302 pp., 1980, $42.00.

Principles of Mineral Behaviour, Geoscience Texts, vol. 1, J. D. C. McConnell, Elsevier, New York, x + 257 pp., 1980, $45.00 cloth, $24.95 paper.

A Priori Prediction of Roundoff Error Accumulation in the Solution of a Super-Large Geodetic Normal Equation System, NOAA Prof. Pap. 12, Peter Meissl, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Rockville, Md., x + 128 pp., 1980.

Radio Interferometry Techniques for Geodesy, NASA Conf. Publ. 2115, National Aeronautics and Space Administration, Washington, D.C., vll + 493 pp., 1980.

Scientific, Technological and Institutional Aspects of Water Resource Policy, AAAS Selec. Symp. 49, Y. Y. Haimes (Ed.), American Association for the Advancement of Science, Washington, D.C., xlv + 128 pp., 1980.

Classified

EOS offers classified space for Positions Available, Positions Wanted, and Services, Supplies, Courses, and Announcements. There are no discounts or commissions on classified ads. Any type that is not publisher's choice is charged for at display rates. EOS is published weekly on Tuesday. Ads must be received in writing on Monday 1 week prior to the date of the issue required.

Replies to ads with box numbers should be addressed to: Box ____, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009

POSITIONS WANTED
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Rates per line
1–5 times—$2.50, 6–11 times—$1.95
12–26 times—$1.75

POSITIONS AVAILABLE

Exploration Geophysicist-University of Oklahoma. The School of Geology and Geophysics at the University of Oklahoma will hire an experienced exploration geophysicist to fill the Frank and Betty Schultz Professorship, and is seeking nominations and applications for the position. The person must be a distinguished scientist who has made important contributions in exploration geophysics through research. Preference will be given to a scientist whose specialty is seismic properties of earth materials and who has earned the Ph.D. The Schultz Professor will provide leadership and guidance in establishing a quality teaching and research exploration geophysics group. The University of Oklahoma has recently made a strong commitment to the earth sciences with the establishment of a College of Geosciences, to be housed in a new building. The School of Geology and Geophysics will expand from its present faculty of 16 to 26 faculty members by 1986. This will include three scientists in the exploration geophysics area, five in structure-tectonophysics-solid earth geophysics and others in stratigraphy-paleontology, geochemistry-petrology, and energy resources.

Applications are due April 30, 1981. Inquiries, nominations, and applications should be sent to John Wickham, Director, School of Geology and Geophysics, University of Oklahoma, Norman, OK 73019

The University of Oklahoma is an equal opportunity employer

Lunar Curatorial Laboratory Manager. Northrop Services, Inc. has operated and maintained the NASA Lunar Curatorial Laboratory at the Johnson Space Center, Houston, Texas since its inception. We are now searching for a manager candidate with a Ph.D. in geology or geochemistry, evidence of administrative skills and a record of publication in the study of lunar samples and or meteorite investigations. Position involves supervision of 38 technical, scientific and clerical employees. Interested persons should send resume, including publications and references to W. B. Kurz, Manager of Personnel Services, Northrop Services, Inc. P.O. Box 34416, Houston, TX 77034

NSI is an equal opportunity affirmative action employer

Physical Oceanographer/ Geophysical Fluid Dynamicist

Arete Associates, a growing research firm, located in Southern California, engaged in theoretical and empirical physical oceanography, is offering permanent, full-time positions. Candidates require Ph.D. (or equivalent experience) in physical oceanography or geophysical fluid dynamics. Salaries are competitive and negotiable, based on qualifications. Arete offers a fringe benefit package of superior quality. Qualified candidates should send resumé, salary history, and list of professional references to:

Personnel Administrator
Arete Associates
P.O. Box 350
Encino, CA 91316

An equal opportunity employer M/F.

Acadia University. The Department of Geology, Acadia University, is seeking a head, beginning July 1, 1981. Preference will be given to applicants with experience and research interests in petroleum geology and related fields and/or energy resources. Rank and salary will be appropriate to qualifications. The successful candidate will assume leadership of an established, vigorous and growing department with five faculty members, and over 100 B.Sc. and M.Sc. candidates. Responsibilities include teaching at undergraduate and graduate levels, and academic planning and development in the specialty area.

A letter of application together with a curriculum vitae and names of three referees should be sent by March 15, 1981 to Dr. Earnest E. Zinck, Dean of Science, Acadia University, Wolfville, N.S., B0P 1X0.

Faculty Position: University of Iowa. The Department of Physics and Astronomy anticipates one or two openings for tenure track faculty in August 1981. Research specialties for which substantial resources are available are magnetospheric and auroral physics and space and laboratory plasma physics, both theoretical and experimental. Other specialties of interest are astronomy, astrophysics, elementary particle physics, atomic physics, condensed matter, and low energy nuclear physics. The positions involve undergraduate and graduate teaching, guidance of research students, and personal research. Interested persons should send a résumé, a statement of research interests, and the names of three professional references to Search Committee, Department of Physics and Astronomy, University of Iowa, Iowa City, IA 52242.

The University of Iowa is an equal opportunity/affirmative action employer.

Sediment Transport/Geological Oceanography, North Carolina State University. A tenure track position is available in the Department of Marine, Earth and Atmospheric Sciences at the level of assistant or associate professor. Applicants should have a thorough understanding of sediment transport, and a general background in geological oceanography. A Ph.D. is required. The candidate will be expected to strengthen the graduate teaching and research programs. The applicant's research interests can be theoretical, experimental, or observational, but must involve quantitative examination of marine sediment transport. Applicants should forward a resume, including a list of courses taken/taught, and the names of at least three references to Dr. Charles A. Nittrouer, Chairman, Search Committee, P.O. Box 5068, NC State University, Raleigh, NC, 27650. Application materials should be sent by March 31, 1981.

North Carolina State University is an equal opportunity/affirmative action employer.

Faculty Appointment/Colorado State University. The Department of Earth Resources, Colorado State University invites applications for a tenure track appointment with emphasis on active research experience in remote sensing, and an interest in teaching graduate and undergraduate students beginning September 1981. The candidate is expected to have a Ph.D. degree in geology, watershed sciences or in a related field and is expected to develop and maintain a vigorous research program with special emphasis on the application of state-of-the-art remote sensing techniques to the investigation of natural resource phenomena. The candidate is expected to teach undergraduate and graduate courses in the application of remote sensing to natural resources.

Rank and salary are open and dependent on experience and qualifications of the applicant.

Applicants are invited to submit curriculum vitae, three letters of reference and a letter describing research and teaching interests to Dr. H. S. Boyne, Department of Earth Resources, Colorado State University, Fort Collins, Colorado 80523/(303) 491-5298.

Deadline for receipt of applications is April 15, 1981.

CSU is an EOE/AA E.O. Office. 314 Student Serv. Bldg.

Geophysicist Department of Earth Sciences, University of California, Riverside. Applications are invited for a (100% time) sabbatical leave replacement, as visiting lecturer in geophysics, in the Department of Earth Sciences, for the academic year 1981–1982.

A broadly-based person who has teaching interests in applied geophysics is desired. A Ph.D. is a prerequisite. Salary in the $18–19,000 range. Duties will include teaching both undergraduate and graduate courses in two or more of the following areas, depending upon the background of the applicant selected: heat flow, electrical or seismic exploration, and data processing.

A complete resume, including the names and addresses of three references, should be sent by March 23, 1981 to: Dr. T-C Lee, Chairman, Search Committee, Department of Earth Sciences, University of California, Riverside, CA 92521, Telephone (714) 787-4508.

Equal opportunity/affirmative action employer.

Geochemistry/Brittle Deformation, University of New Brunswick. The Department of Geology has a tenure track position available from July 1, 1981 at assistant professor or higher level. The successful applicant will be expected to teach both undergraduates and graduates as well as carrying out research and supervising graduate students.

Applications will be accepted in the following fields: geochemistry of ore bodies, exploration, environmental or soil geochemistry, brittle deformation, rock mechanics or site engineering.

Applicants should have a Ph.D. and preferably, post doctoral experience. Applications including a curriculum vitae and names of three referees should be sent to P. F. Williams, Chairman, Department of Geology, University of New Brunswick, Fredericton, N.B. E3B 5A3.

Battelle, Pacific Northwest Laboratories. Applications are invited for a postdoctoral position in geophysics with emphasis on middle or upper atmospheric research at the Battelle Observatory in Richland, Washington. Stipend will be $18,000 initially; the position offers the possibility of a permanent research position at the end of the postdoctoral appointment. Address inquiries to R. A. Stokes, Battelle Observatory, Battelle, Pacific Northwest Laboratories, P.O. Box 999, Richland, WA 99352.

Oceanographic Mooring Technician. The Marine Science Program at North Carolina State University (Raleigh) is expanding its oceanographic technical services group and is currently seeking a technician familiar with the design and deployment of deep-sea current meter mooring arrays, as well as with standard shipboard oceanographic sampling techniques.

Qualifications include a degree in science or engineering with some electronics background and two years field experience or an equivalent combination of education and experience. Salary commensurate with education and experience. Send resume and names of references to Personnel Services, North Carolina State University, P.O. Box 5087, Raleigh, NC, 27650.

An equal opportunity employer.

Vincent C. Kelley and Leon T. Silver Graduate Fellowships

THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the University of New Mexico invites applications for the Vincent C. Kelley and Leon T. Silver Graduate Fellowships. The fellowships will be awarded on the basis of the scholastic record and academic promise of graduate applicants. Each fellowship will provide for a generous living stipend of $1,000/month for 9 to 12 months, and up to $2,000/year for travel and research expenses. The Caswell Silver Foundation will pay all tuition and university fees. The awards are made on an annual basis, but may be renewed for up to three years as long as the student maintains excellent academic standing and shows evidence of significant progress in research. Preference will be given to, but is not restricted to, applicants for the Ph.D. program.

An application for admission to the UNM Graduate Program, transcripts, Graduate Record Exam results (verbal, math & geology), three letters of reference and a brief statement of research goals are required for consideration for the fellowships. Application materials may be obtained from:

Rodney C. Ewing
Chairman
Department of Geology
University of New Mexico
Albuquerque, New Mexico 87131

The deadline for applications is April 1, 1981 for the Fall semester of 1981.

The Caswell Silver Distinguished Professorship in Geology

THE UNIVERSITY OF NEW MEXICO

The Department of Geology of the University of New Mexico is pleased to invite nominations or applications for the Caswell Silver Distinguished Professorship in Geology. This endowed professorship shall be awarded for periods of up to two years to earth scientists of distinguished accomplishment and international reputation. The professorship may be held by scientists of all specialties of the earth sciences in the broadest sense, and the major criterion for selection is that the individual be an active, productive leader in his or her field of research. The recipient must carry out a vigorous research program while in residence at UNM. The recipient is expected to interact with the faculty and students of the Department and to provide one or more seminars, in an advanced topic of his/her choice, during each academic year. The Foundation will provide unusually advantageous remuneration commensurate with the distinguished nature of the appointment. In addition, a generous allocation for travel and operating expenses (to include secretarial support, analytical services in department laboratories, use of field vehicles, and preparation of manuscripts) will be provided.

Applications or nominations should include a detailed resume and brief statement of major research accomplishments. Applications or nominations should be forwarded to:

Rodney C. Ewing, Chairman
Department of Geology
University of New Mexico
Albuquerque, New Mexico 87131

The Caswell Silver Foundation is an equal opportunity employer.

Assistant Professor: Planetary Sciences. The Astronomy Department at Cornell University invites applications for a faculty position in the general area of planetary sciences. The position is a tenure track assistant professorship to begin September 1981 or 1982. The department has a strong program of solar system studies, emphasizing telescopic, radar, and spacecraft observations of planetary surfaces and atmospheres, with associated theoretical investigations in the areas of atmospheric dynamics, planetary interiors, and celestial mechanics, as well as supporting laboratory programs.

Outstanding research ability is the most essential qualification. Teaching ability, including the supervision of graduate research students, is also an important requirement.

Candidates should send a resume with bibliography and a summary of research interests and experience to:

Professor Yervant Terzian
Chairman, Department of Astronomy
Space Sciences Building
Cornell University
Ithaca, NY 14853

Candidates should also arrange for three letters of recommendation to be sent to the above address. All application materials must be received by April 30, 1981.

Cornell University is an equal opportunity/affirmative action employer.

Sedimentary Geologist/Micropalaeontologist, Washington University. The Department of Earth and Planetary Sciences, Washington University, has available a tenure track, assistant professorship position, beginning in the 1981–82 academic year for a geoscientist with research interests in diagenesis of sediments or in micropaleontology.

The successful candidate must have the following attributes: demonstrated creativity and promise of excellence in research and teaching; intent to develop a vigorous graduate research program; desire to teach courses in field of interest and related fields of geoscience at undergraduate and graduate levels.

Send resume, statement of future research interests, and names of at least three references, to Larry Haskin, Chairman, Department of Earth & Planetary Sciences, Washington University, St. Louis, MO 63130. Applications received through April 15, 1981.

Washington University is an equal opportunity/affirmative action employer.

Faculty Position in Physical Oceanography. The Department of Marine, Earth and Atmospheric Sciences at North Carolina State University invites applications for a nine-month, hard money, tenure track position at the assistant or associate professor level for a physical oceanographer, specializing in the numerical modeling of oceanic flows.

Applicants should have a strong background in geophysical fluid mechanics and the abilities to develop a funded research program and graduate level courses. Presently funded areas at NCSU include estuarine, coastal and deep-water oceanography.

Send curriculum vitae and the names of three references by March 31, 1981 to Professor G. S. Janowitz, Chairman, Search Committee in Physical Oceanography, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, P.O. Box 5068, Raleigh, NC 27650.

North Carolina State University is an equal opportunity/affirmative action employer.

Solid Planet Geophysicist/Texas A&M University. The Department of Geophysics at Texas A&M University is pleased to announce availability of a junior level, tenure track faculty position. The department emphasizes solid earth geophysics with concentrations in tectonophysics, geodynamics and internal structure. We are seeking a talented and active researcher and teacher who will complement, strengthen, and broaden current areas of expertise. There are excellent opportunities for interaction and collaboration with members of our department as well as those in the departments of oceanography and geology and in the center for tectonophysics. Qualified scientists are requested to send resumés to Neville L. Carter, Head, Department of Geophysics, Texas A&M University, College Station, TX 77843.

Texas A&M University is an equal opportunity employer.

Chemical Oceanographer. Research associate, M.S., marine organic geochemistry and its relation to ocean productivity. Cooperative Institute of Marine and Atmospheric Sciences, University of Miami and National Oceanic and Atmospheric Administration, contact Chairman Search Committee, D. K. Atwood, NOAA/AOML, 15 Rickenbacker Causeway, Miami, FL 33149.

Seismologist. The Department of Geology at the University of Illinois, Urbana-Champaign, has an opening for a tenure track position at the assistant professor level, beginning during the 1981–82 academic year. A Ph.D. is required. The applicant should have a strong background in geology, and post-doctorate experience is desirable. Candidates with interests and experience in tectonic studies based on seismological observations will be given preference. The successful candidate is expected to develop an active research program to complement existing programs in geodynamics, solid earth geophysics, and rock physics. There is also opportunity for interaction with programs in the Departments of Theoretical & Applied Mechanics and Civil Engineering, and the Interdisciplinary Materials Research Laboratory. Send resumé and names of three references to: Dr. John Hower, Head, Department of Geology, University of Illinois, 245 Natural History Bldg., 1301 W. Green St., Urbana, IL 61801 (Telephone: 217/333-3542). Applications should be received by April 15, 1981.

The University of Illinois is an affirmative action/equal opportunity employer.

Faculty Position Petrology Tectonics. The Department of Geology at Stanford University has an opening for a full professor to work half-time in the fields of petrology and tectonics. We seek someone who is interested both in teaching and in conducting research on the petrology and tectonics of continental margins. Applicants are invited to send letter of application, a resume and the names of three references by March 31, 1981 to:

Allan Cox
School of Earth Sciences
Stanford University
Stanford, CA 94305

As an equal opportunity and affirmative action employer, Stanford welcomes applications from women and minorities.

Upper Ocean Modeler. Two postdoctoral positions in upper-ocean modelling available in the mesoscale air-sea interaction group at the Florida State University. Ph.D.'s with background in fluid dynamics, theoretical physical oceanography, dynamic meteorology, numerical analysis, or physics are invited to apply. Salary range $19,000–$21,500/year. Positions are supported by Office of Naval Research and may be filled at any time after April 1, 1981. Send vitae and names of three references to Professor James O'Brien, The Florida State University, Tallahassee, FL 32306.

The University is an equal opportunity employer.

Economic Geologist. The Department of Geoscience at New Mexico Institute of Mining & Technology wishes to add staff members in the field or ore deposits and/or energy resources, petrology, structural geology and geomorphology remote sensing. Applications with expertise in any of these fields will be considered but preference will be given to those with proven capabilities in economic geology. If successful, candidates will be expected to develop an active research program in addition to participating in instruction. Rank open. Send resumes, three references and statement of research interest and plans to: Dr. A. J. Budding, Chairman Search Committee, Geoscience Department, New Mexico Institute of Mining & Technology, Socorro, NM 87801. Closing date March 31, 1981.

AA/EOE.

Seismologist. The Tennessee Earthquake Information Center (TEIC) is seeking applications for the position of seismologist beginning July 1981. The position will also be a joint tenure track appointment in the Department of Geology. Primary duties, however, are with TEIC; teaching will be on a time-available basis, not to exceed one course per semester.

The Ph.D. is required and experience with telemetry networks is highly desirable. The successful applicant will be expected to assume co-PI responsibilities on the Memphis and Southern Appalachian seismic networks, as well as actively pursue externally funded research projects digital data processing, seismic hazard assessment and public information are other aspects of the job.

The TEIC is a research organization of Memphis State University and the State of Tennessee, 12-month salary ($25,000 and above) depends on background and experience. Position is ¾ state supported, ¼ (summer) from external sources.

Application deadline: 15 April 1981. Send resume, publications list, short statement of research interests, and names and addresses of four referees to:

Arch Johnston, Director
Tennessee Earthquake Information Center
Memphis State University
Memphis, Tennessee 38152

Memphis State University is an equal opportunity/affirmative action employer.

Planetary Science Geology, California Institute of Technology. The Division of Geological and Planetary Sciences desires to make an assistant professor appointment in planetary surface geology for the purpose of teaching and research in interpretation of planetary history from earth- and spacecraft-based observations of planetary surfaces. The division consists of about 25 faculty members specializing in geology, geochemistry, geophysics, and planetary science. The Jet Propulsion Laboratory, seven miles north of the campus, has over 100 scientists actively involved in space research. If interested please write, with resume, to Barclay Kamb, Chairman, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125.

An equal opportunity employer.

Head: Earth Resources Branch, NASA/Goddard Space Flight Center. GS-1330-14/15: $37,871–$50,112 per annum, full-time permanent. The Earth Survey Applications Division, Applications Directorate, NASA/Goddard Space Flight Center invites applications for the open position of Head, Earth Resources Branch. The incumbent of this position is responsible for planning, managing, and conducting broad programs in earth resources remote sensing basic and applied research and data analysis, emphasizing the development and demonstration of applications of remote sensing of earth resources from earth orbiting satellites. The primary areas of research in the Branch are land use management, vegetation and ocean including agriculture/forestry/rangeland and environmental monitoring utilizing remotely sensed data and advanced technologies. Also, significant effort is dedicated to sensor data evaluation in terms of applications and scientific utility, and to specification of data acquisition and information extraction systems which best meet user scientific and resource management needs. An advanced degree in earth or physical sciences is required with education in the vegetation sciences, land use or environmental monitoring being specifically preferred. Candidates should also have several years of progressively more responsible experience in the conduct, guidance and management of remote sensing research programs and clear evidence of a strong research background indicating senior research scientist stature.

Resumes/SF 171's should be sent to:
Dr. Robert D. Price, Assistant Chief
Earth Survey Applications Division
Code 920
Goddard Space Flight Center
Greenbelt, MD 20771

Deadline for applications is April 30, 1981

Assistant Professor of Mining. Applied geophysics program to begin July 1, 1981. Applicants should have a doctorate degree, practical experience and publications. Ability to supervise graduate students is essential. Salary commensurate with qualifications and experience. Send resume and the names and addresses of three references by April 1, 1981 to Prof. John T. Kuo, 828 S.W. Mudd Bldg., Henry Krumb School of Mines, Columbia University, New York, NY 10027.

Columbia University is an equal opportunity/affirmative action employer

Physical Oceanographer. The Department of Marine Science and Engineering, North Carolina State University, has an immediate opening for a postdoctoral research associate. Research will be directed toward equatorial circulation dynamics, including seasonal and higher-frequency variability. Participation in fieldwork will be required. Qualifications include a Ph.D. or equivalent in physical oceanography or geophysical fluid dynamics and experience in the analysis of oceanographic time series. The initial appointment will be for 2 years, with a possible continuation subject to availability of funds. Salary is competitive and negotiable, based upon qualifications. Applicants should send the names of three references, a resume, and publication list to Robert H. Weisberg, Department of Marine Science and Engineering, P.O. Box 5923, NC State University, Raleigh, NC 27650.

Research Assistants/Utah State University. Exciting opportunities at the frontiers of knowledge exist for graduate and undergraduate research assistants in the Department of Electrical Engineering at Utah State University. USU, located at the base of the Wasatch Mountains, is engaged in ground-breaking investigations in many critical fields. Get involved in environmental sensing, digital electronics, microprocessor applications, electro-optics, or computer engineering. Do space and atmospheric physics with state-of-the-art instrumentation on the ground, in rockets, or aboard the space shuttle. For details on these and other projects, contact Doran J. Baker, Head, Department of Electrical Engineering, UMC 41E, Utah State University, Logan, UT 84332 (telephone 801/750-2840). USU provides opportunities based only upon performance.

Geophysicist. The Geology Department at the University of Southwestern Louisiana in Lafayette, Louisiana invites applications for an anticipated research/teaching opening in geophysics. Responsibilities will include one-half time in seismic investigation of geopressured-geothermal reservoirs of South Louisiana and one-half time teaching geophysics and supervising graduate students. The successful applicant will be familiar with exploration seismic data acquisition, processing, and interpretation. The Ph.D. or Masters with experience, is required. Salary range is $23,000 to $35,000 per 12 month.

The position is expected to be filled in the Spring of 1981 or as soon as possible thereafter.

To apply please direct a resume, three letters of recommendation, and any other pertinent materials to: Dr. Gary L. Kinsland, Geology Department, University of Southwestern Louisiana, Lafayette, LA 70504

Research and Data Systems, Inc./Scientific Programmers and Programmer Analysts. Immediate openings for persons with B.S. in science or math and at least two years experience with FORTRAN or PL/1 on IBM systems. Work involves data processing and analysis from a satellite based remote sensing systems. Experience with time sharing systems preferred. Also have openings for staff scientists with strong programming background. Send resume in confidence to Research and Data Systems, Inc., 9430 Annapolis Road, Lanham, MD 20801. Telephone: (301) 459-0001.

Geochemistry/Geophysics: California Institute of Technology. The Division of Geological and Planetary Sciences seeks to make a faculty appointment in geochemistry/geophysics for the study of hydrothermal fluid systems in the earth's crust. We seek a geoscientist with strong research potential in hydrothermal systems and in fluid-rock interactions in the crust, and with particular interest in developing new, integrated geological, geochemical, geophysical approaches to the understanding of those systems and their associated mineral deposits. Appointment is preferably at the junior (assistant professor) level, but more senior applicants will be considered. Please write to Barclay Kamb, Chairman, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125.

An equal opportunity employer.

Program Director, Petrology Program. The National Science Foundation's Division of Earth Sciences is seeking qualified applicants for program director, petrology program. This position is excepted from the competitive civil service at the EC-14/EP level (equivalent to the GS-14/15), $37,871–$57,912 (limited by statute to $50,112.50) per annum, and will be filled on a rotational basis for 2 years. Candidates should have a Ph.D. in one of the earth sciences. Equivalent experience in research and in the administration of large, multidisciplinary research programs may be substituted for the degree. A broad general knowledge of geologic research and familiarity with the U.S. scientific community are also required. Candidates should submit a resume to the National Science Foundation, Personnel Administration Branch, Rm. 212, 1800 G St., NW., Washington, DC 20550. Attn: E. Paul Broglio, EX 81–26. For further information call (202) 357-7841. This position is open until filled.

NSF is an equal opportunity employer.

Research position. Applications are invited for faculty and research engineer positions in the Department of Mechanical Engineering or the Utah Water Research Laboratory at Utah State University. Ranks range from assistant professors to professor to research professor on the non-tenure track, or research engineer. Expertise sought in the computer modeling of fluid-thermal systems for applications to solar and other renewable resource developments and specifically to salt gradient solar ponds. Professor position involves teaching and requires a Ph.D. in mechanical or chemical engineering or related sciences. Research engineers would be full time researchers and require MS degree in stated disciplines. Applicants send, by April 1, 1981, resume including list of publications and three letters of reference to: Dr. A. P. Moser, Head Department of Mechanical Engineering, UMC-41 Utah State University, Logan Utah 84322

An affirmative action/equal opportunity employer

Geophysicist North Carolina State University—Raleigh. The Department of Marine, Earth and Atmospheric Sciences invites applications for a presently available tenure track position in geophysics. Rank and salary are open, depending on qualifications and experience. A Ph.D. is required. Applied or exploration geophysics orientation are preferable, however, other specializations in geophysics also will be considered.

Primary responsibilities will include generating and conducting research programs as well as teaching graduate courses in geophysics. The department presently consists of 31 regular faculty members including 16 in the areas of geology and geophysics. Please send resume and names of three references to Prof. I. J. Won, Search Committee Chairman, Department of Marine, Earth and Atmospheric Sciences, North Carolina State University, Raleigh, NC 27650, USA. We hope to make a final decision prior to May 31, 1981.

North Carolina State University is an equal opportunity/affirmative action employer.

Fellow and Research Fellows. THE AUSTRALIAN NATIONAL UNIVERSITY invites application for appointment to the post of fellow (one position) and research fellow (two positions) in the Research School of Earth Sciences from those holding a Ph.D. degree in a relevant field. The research of the Geophysical Fluid Dynamics group has been in two main areas: laboratory and theoretical models of convection and mixing in the ocean; and studies of fluid dynamical processes in the interior of the earth. Recent work has included studies of mixing across oceanic fronts, the melting of icebergs in a stratified environment, and fluid processes relevant to the formation of ore deposits and of basaltic igneous intrusions. The group has a well-equipped laboratory, including a DEC computer for data logging and analysis, and the staff at the present comprises Professor J. S. Turner, two research fellows and two technical officers. For the appointment as fellow, preference will be given to a person with experience of the application of fluid mechanics to both oceanographic and solid earth problems, and a strong background in both theoretical and experimental work. For a highly qualified applicant, an appointment at the senior fellow level would be considered. Candidates for the research fellow posts should have qualifications and experience related to at least one of the fields outlined above and are invited to submit an outline of their proposed research program with their application. The successful applicants will be free to conduct their own independent research within the overall program of the group, and there are excellent opportunities to pursue interdisciplinary research with other groups in the school. Further information can be obtained from Professor Turner. Salary will be according to qualifications within the ranges: Senior fellow $29917–$34870 per annum; fellow $22301–$29877 per annum; research fellow $19132–$24972 per annum Australian currency. Present exchange rate $A1 = $US1.16. Appointment as a research fellow will be up to three years with possible extension to five years and as a senior fellow/fellow—five years with possible reappointment to age 65. Reasonable appointment expenses are paid and assistance with finding accommodation is provided for an appointee from outside Canberra. Superannuation benefits are available. The University reserves the right not to make an appointment or to make an appointment by invitation at any time. Applicants should write to the Registrar, Australian National University, PO Box 4, Canberra ACT 2600, Australia with whom applications close on 17 April 1981.

Meetings

Geodesy Session at Astrodynamics Meeting

AGU will cosponsor a special session on geodesy at the 1981 Astrodynamics Conference sponsored by the American Astronautical Society (AAS) and the American Institute of Aeronautics and Astronautics (AIAA). The conference is scheduled for August 3–5 in North Lake Tahoe, Nevada.

The special session will focus on the interface between geodesy and satellite-related astrodynamics and celestial mechanics. In addition to invited papers, a limited number of contributed papers will be considered. Prospective authors must submit 1000-word abstracts to Paul J. Cefola, Technical Program Chairman, Mail Station 64, C.S. Draper Laboratory, 555 Technology Square, Cambridge, Mass. 02139. Abstracts should be clearly marked 'Geodesy Special Session—Contributed Paper' and should arrive no later than March 20.

AGU members are invited to attend the conference and may register at AAS/AIAA member rates. For more information about registration, contact the general chairmen for the meeting: Alan L. Friedlander, Science Applications, Inc., 1701 East Woodfield Road, Schaumburg, Ill. 60195, or Bernard Kaufman, Naval Research Laboratory, Code 7933, Washington, D.C. 20375.

AGU SCHOLARSHIP ASSISTANCE FOR THE ACADEMIC YEAR 1980–1981

The June Bacon-Bercey Scholarship in Atmospheric Sciences for Women

Scholarship assistance in the amount of $400 will again be made available to a woman who intends to make a career in the atmospheric sciences. The award, which is provided through a gift from June Bacon-Bercey, a noted practicing meteorologist, will be made on the basis of academic achievement and promise. To be eligible for this scholarship, a candidate must be one of the following at the time of application:

- a first-year graduate student in a program leading to an advanced degree in the atmospheric sciences;
- an undergraduate in a bachelor's program leading to a degree in the atmospheric sciences, who has been accepted for graduate study in the field; or
- a student at a 2-year institution offering at least 6 semester hours of atmospheric sciences, who has been accepted for a bachelor's degree program in the atmospheric sciences and who has completed all of the courses in atmospheric science offered at the 2-year institution.

Application forms are available from the American Geophysical Union, Member Programs Division, 2000 Florida Avenue, N.W., Washington, D.C. 20009 (202/462-6903). Selection of the awardee will be made by the AGU Subcommittee on Women in Geophysics, in consultation with the AGU Meteorology Section.

DEADLINE FOR RECEIPT OF APPLICATIONS IS MARCH 16, 1981

Early Planetary Crusts and Magma

A workshop entitled 'Magmatic Processes in the Generation of Early Planetary Crusts: Magma Oceans and Stratiform Layered Complexes,' scheduled for August 3–7, will explore the analogies between the oldest rocks returned from lunar highlands and the rocks of terrestrial layered intrusions. The lunar highlands rocks are thought by many investigators to have formed by crystallization of a primordial magma ocean.

In addition there will be discussions of the processes that operated during and after crystallization of both terrestrial and lunar magmatic cumulate rocks, and there will be an attempt to establish collaborative research efforts designed to clarify the petrogenesis of both the lunar samples and their terrestrial analogs.

Attendance will be limited, and preference will be given to scientists interested in participating in collaborative research. For further information, contact one of the conveners: D. Walker, Hoffman Laboratory, Harvard University, Cambridge, Mass. 02138, or I. S. McCallum, Geological Sciences, AJ-20, University of Washington, Seattle, Wash. 98195.

Symposium on Earth Rotation

The International Symposium on 'High-Precision Earth-Rotation and Earth-Moon Dynamics: Lunar Distances and Related Observations' is scheduled for May 25–27 in Grasse, France. Primary purpose of the symposium is to present results from the EROLD (Earth Rotation from Lunar Distances) program.

Other topics to be discussed include new developments related to the dynamics of the earth-moon system, high-precision techniques for determining earth rotation, and the scientific applications of the lunar laser ranging experiment.

The symposium will be held in conjunction with and following the first MERIT workshop. The workshop, limited to active participants in the MERIT program, is scheduled for May 19–21. Additional information can be obtained from G. A. Wilkins, Her Majesty's Nautical Almanac Office, Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, Sussex BN 27 1 R P, United Kingdom. A joint discussion between the workshop group and the symposium group will be held May 22.

For additional information on the symposium, contact O. Calame, CERGA, Avenue Copernic 06130 Grasse, France.

GAP

Electromagnetics

[illegible]

... Radio Sci., Paper 1S0151

6945 Tropospheric propagation
PREDICTION OF ATTENUATION DUE TO RAINFALL ON TERRESTRIAL LINKS
F. Fedi (Fondazione Ugo Bordoni, Viale Trastevere 108, 00153 Roma, Italy)
In this review, attention is confined to rain attenuation and to its influence on the availability of terrestrial radiocommunication systems operating at frequencies above 10 GHz. The availability objectives recently established in the CCIR for digital systems, the information necessary and a calculation procedure applicable for system design are examined. Various methods for predicting attenuation due to rain are compared and reviewed. Present trends for the use of frequencies above 10 GHz in terrestrial systems are illustrated and areas in which further study is needed are indicated.
Radio Sci., Paper 1S0194

Exploration Geophysics

0910 Computer applications
A HYBRID THREE-DIMENSIONAL ELECTROMAGNETIC MODELING SCHEME
See 0970 Instrumentations and techniques
F.H. Lee (Bureau of Mining Building, Room 414, University of California, Berkeley, CA 94720) D. F. Pridmore and H.F. Morrison
We present an efficient numerical method for computing electromagnetic (EM) scattering of arbitrary three-dimensional (3-D) local inhomogeneities buried in a uniform or two-layered earth.
In this scheme the inhomogeneity is enclosed by a volume whose conductivity is discretized by a finite-element mesh and whose boundary is only a slight distance away from the inhomogeneity. The scheme uses two sets of independent equations. The first is a set of finite-element equations derived from a variational integral, and the second is a mathematical expression for the fields at the boundary in terms of fields inside a homogeneous boundary. The Green's function is used to derive the second set of equations. An iterative algorithm has been developed to solve these two sets of equations ... the scattered fields anywhere may then be obtained by performing volume integrations over the inhomogeneous region.
The scheme is used for modeling 3-D inhomogeneities with plane-wave and magnetic dipole sources. The results agree with earlier model analyses using the finite-element technique.
Geophysics, Vol. 46, No. 5

0920 Magnetic and electrical methods
DEPTH OF INVESTIGATION OF COLLINEAR ELECTRODE ARRAYS OVER HOMOGENEOUS ANISOTROPIC HALF-SPACE IN DIRECT CURRENT METHODS
R.K. Bhattacharya (Department of Applied Geophysics, Indian School of Mines, Dhanbad 826004, India) M. K. Sen
The definition of 'depth of investigation' as suggested by Evjen (1938) [subsequently used by Roy and Apparao (1971) also for the study of depth of investigation of electrode arrays for a given current method for homogeneous isotropic earth] has been used to study the depth of investigation of various collinear electrode arrays for a homogeneous anisotropic half-space. It has been shown that some simple transformations are to be applied to the expressions of normalized depth of investigation characteristic (NDIC) of the same arrays over homogeneous isotropic earth to obtain normalized depth of investigation characteristic of various arrays placed over homogeneous anisotropic earth. The novelty of anisotropy is that the depth of investigation of collinear electrode arrays over homogeneous anisotropic half-space bears an inverse relationship with the coefficient of anisotropy and also depends upon array length and dip of the plane of stratification. The effect of the coefficient of anisotropy is most pronounced for horizontally stratified anisotropic earth and is independent of it for vertically stratified anisotropic earth—entirely consistent with the concept of the "paradox of anisotropy." The depth of investigation of all the collinear arrays for inclined stratification lies somewhere between the values obtained for horizontal and vertical stratifications.
Geophysics, Vol. 46, No. 5

0930 Seismic methods
TIME-DEPTH AND VELOCITY-DEPTH RELATIONS IN SEDIMENTARY BASINS—A STUDY BASED ON CURRENT INVESTIGATION IN THE ARCTIC ISLANDS AND AN INTERPRETATION OF EXPERIENCE ELSEWHERE
C. H. Acheson (Panarctic Oils Ltd., P.O. Box 190, Calgary, Alberta, Canada T2P 2H6)
Velocity of P-waves in the Arctic Islands obeys the same power-law equations (1) $t = az^n + b$, (2) $V = cz^{1-n}$ that apply to Western Canada (Acheson, 1963). They appear to be closely related to the theoretical one-sixth power law ($n = 5/6$) derived by Gassmann (1950), Brandt (1955), and others.
Equations (1) and (2) are piece-wise continuous at any given location and consist of a number of discrete segments corresponding to geologic units, each characterized by a distinct set of values for a, b, c, and n. Except for a limited number of velocity anomalies such as permafrost, these units relate to formations or groups of formations. Velocity changes in a, b, and n correspond to major changes in lithology, pressure, or compaction. Velocity fluctuations within the formations caused by variation in grain size, porosity, fluid-to-matrix coupling, and so on are not indicated in this analysis, and the velocity-depth relation refers to secular velocity variation only.
Correlation of reported velocity findings from many parts of the world through a common relationship to the one-sixth power law suggests this system of equations has widespread, possibly global, application to important geophysical problems of many kinds.
Geophysics, Vol. 46, No. 5

0930 Seismic methods
DEPTH MIGRATION OF IMAGED TIME SECTIONS
See 0910 Computer applications
Kenneth L. Larner (Western Geophysical Company, P. O. Box 2469, Houston, TX 77001) Leslie Hatton, Bruce S. Gibson, and I-Chi Hsu
Some of the leading approaches to the migration of seismic sections—the Kirchhoff-summation method, the finite-difference method, or the frequency-domain method—readily migrates seismic reflections to their proper positions when overburden velocities vary laterally. For inhomogeneous media, the diffraction curve for a localized, buried scatterer is no longer hyperbolic and its apex is displaced laterally from the position directly above the scatterer. Hubral observed that the Kirchhoff-summation method images seismic data at emergent "image ray" locations rather than at the desired positions vertically above scatterers. In addition, distortions in diffraction shapes lead to incorrect imaging (i.e., incomplete diffraction collapse) and, hence, to further displacement errors for dipping reflections.
The finite-difference method has been believed to continue waves downward correctly through inhomogeneous media. In conventional implementations, however, both the finite-difference method and frequency-domain approach commit the same error that the Kirchhoff method does. Synthetic examples demonstrate how conventional migration fails to image events completely.
Hubral's solution to this migration problem is two- (or three-) dimensional mapping of imaged time sections into depth. This mapping, "depth migration," replaces simple vertical conversion from time to depth. Such depth migration can be postponed until after efficient image-ray modeling has been performed to (1) support the final choice of velocity model, and (2) determine whether depth migration is necessary.
Comparisons between depth-migration and conventionally depth-converted sections of both synthetic and field data properly show that significant lateral displacement is often required to position reflectors properly. Monte Carlo studies show that the lateral corrections can be important not only in absolute terms but also in relation to errors expected from an inaccurate velocity model.
Geophysics, Vol. 46, No. 5

Hydrology

3115 Groundwater
PRECONSOLIDATION STRESS OF AQUIFER SYSTEMS IN AREAS OF INDUCED LAND SUBSIDENCE
T. L. Holzer (U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California, 94025)
Aquifer systems in the Eloy-Picacho area, Arizona, the Houston-Galveston area, Texas, and the Tulare-Wasco area and Santa Clara Valley, California, appear to have been overconsolidated by an amount that ranged approximately from 1.6 to 6.2 bars (16 to 63 m of water) before man began to withdraw groundwater from them. The relation between land subsidence and water-level decline in these areas consists of two linear segments. In these areas subsidence per unit water-level decline was approximately constant until water levels had declined an amount that ranged from 16 to 63 m. When water levels declined past these values, subsidence per unit water-level decline increased to larger constant values. Although slow drainage from aquitards may have contributed to this response, it is interpreted here to be caused primarily by natural overconsolidation of the compacting part of the aquifer system. The water-level decline at which the ratio of subsidence to unit water-level decline changed indicates approximately the amount by which the preconsolidation stress exceeded the overburden stress on the aquifer system that existed before groundwater withdrawals began. (Subsidence, groundwater, preconsolidation)
Water Resour. Res., Paper 1W0207

3140 Limnology
ATMOSPHERIC AMMONIA-NITROGEN: A POTENTIAL SOURCE OF NITROGEN EUTROPHICATION OF FRESH-WATER ANTARCTIC ECOSYSTEMS
E.B. Wodehouse and B.C. Parker (Virginia Tech, Blacksburg, VA, 24061)
Absorption of airborne ammonia volatilized from an Adelie penguin rookery by 2 fresh-water lakes was examined during the 1970–71 austral summer at Anvers Island, Antarctica (64° 46' S, 64° 05' W). One lake was on Humble Island 100 m from a 6000 bird penguin rookery. The second lake was ca. 700 m distant on Norsel Point near a Skua nesting area. Humble Island lake had higher nutrient content and algal species diversity than the Norsel Point lake. Nutrient content of rain, snow and glacial melt appeared to approximate the nutrient concentrations of the Norsel Point lake. However, higher amounts of phosphate, chloride and ammonium at the Humble Island lake reflected the nutrient enrichment caused by the nearby penguin rookery. Evidence suggests microbial decomposition of nitrogenous matter in the guano is followed by volatilization of large amounts of ammonia. Wind was the most important factor regulating ammonia transport from the rookery to the lakes even though increased temperature volatilized greater quantities of ammonia in the immediate rookery area. Ammonia absorption by water traps and cumulative wind data allowed estimation of ammonia taken up by Humble Island lake at a rate of 27 kg/ha/yr and Norsel Point lake at 3.1 kg/ha/yr. When areas and volumes of the lakes were taken into account such absorption rates could provide enough nitrogen to produce a monthly increase of 1.6 mg N/l at the Humble Island lake and 0.03 mg N/l at the Norsel Point lake. These differences can partially explain the differences in nitrogen content of the two lakes which contributes to their differential nutrient enrichment and natural eutrophication. (Gaseous ammonia, natural eutrophication).
Antarctic Res. Ser., Vol. 32, Paper 5

3160 Runoff and streamflow
ANALYZING FLOODPLAIN POLICIES USING AN INTERDEPENDENT LAND USE ALLOCATION MODEL
L. D. Hopkins (Dept. of Landscape Architecture, University of Illinois, Urbana, IL 61801) E. D. Brill, Jr., K. B. Kurtz and H. G. Wenzel, Jr.
A model is described that compares allocations of land uses in terms of aggregate economic rent, taking specific account of the interdependence between floodplain land uses and upstream land uses. Solution of this model by dynamic programming for the Hickory Creek watershed suggests that some restriction of land uses in the floodplain, but not for all subbasins, and some provision of detention, but not for all subbasins, is preferable to the results likely from implementation of typical policies for floodplain management. Determination of target land use patterns through allocation models that account for the interdependence may, therefore, be worthwhile if policy instruments can be developed so that such targets can be attained. (Land use planning, floodplain management, flood routing, dynamic programming).
Water Resour. Res., Paper 1W0231

3160 Runoff and streamflow
LONG-MEMORY FLOW MODELS IN RESERVOIR ANALYSIS: WHAT IS THEIR PRACTICAL VALUE?
V. Klemeš (National Hydrology Research Institute, Environment Canada, Ottawa, Ontario, K1A 0E7, Canada) R. Srikanthan and T.A. McMahon
The theoretical value of long-memory stochastic models lies in their ability to generate time series that resemble long historic records of some geophysical processes better than do short-memory models. Since the use of short-memory streamflow models has become standard practice in reservoir design, it is worth asking whether the suspected theoretical superiority of long-memory models justifies a change in this practice; in other words, whether their theoretical appeal can be translated into better design of storage reservoirs.
This paper analyzes the problem from the point of view of the differences in reservoir performance reliability obtained on the basis of long- and short-memory models fitted to the same historic streamflow record of a length typically encountered in reservoir design. It appears that the differences in reliability resulting from the replacement of one model by the other (shorter memory yields higher reliability) are small compared both to 1) the accuracy of measurement of the socio-economic impact of reliability changes and 2) the accuracy of estimating the reliability itself on the basis of available streamflow records and for economically relevant lengths of reservoir operation periods.
Thus it is argued that, given the socio-economic and hydrologic data typically available for reservoir planning and design, the replacement of short-memory models with long-memory models in reservoir analyses cannot be objectively justified. It is suggested that for a long time to come the use of long-memory models will, in principle, remain equivalent to the use of a small safety factor in the intrinsically inaccurate estimate of reservoir performance reliability. (Stochastic hydrology, time series, storage reservoirs, streamflow regulation).
Water Resour. Res., Paper 80W1749

3180 Water quality
ESTIMATION OF IMPERVIOUS-AREA WASHOFF PARAMETERS
W. M. Alley (U.S. Geological Survey, WRD, 410 National Center, Reston, Virginia 22092)
In recent years many models have been developed which simulate the quality of rainfall runoff from urban areas. Common to many of these models is the use of an exponential washoff equation. This washoff equation is often modified by an availability equation to account for the effects of runoff intensity on constituent washoff. Optimization techniques for estimating the values of coefficients used in these equations have been developed. Application of these techniques to a small urban watershed in south Florida demonstrated considerable variability in the optimized parameter values among different storms and among different constituents. (Urban runoff, stormwater management).
Water Resour. Res., Paper 1W0222

3130 Water Quality
EFFECTS OF FLOODS ON NUTRIENT AND METAL CONCENTRATIONS IN A COASTAL PLAIN STREAM
P. J. Mulholland (Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee) L. A. Yarbro, R. P. Sniffen and E. J. Kuenzler
Water quality in Creeping Swamp, a Coastal Plain stream in North Carolina, was monitored during two floods in 1976. The concentrations of most of the filterable substances studied remained relatively constant, particularly at the upstream station, CP-20, which drained the least disturbed portion of the watershed. Concentrations of NO_3 and dissolved organic carbon (DOC) increased, and concentrations of Cl decreased during the floods at CP-20. At the downstream station, CP-10, which received effluents from a hog farm, concentrations of the filterable forms of N, P, K, and Fe increased markedly during floods. Indications were that increases in concentration of filterable substances during floods may be better indicators of watershed disturbance than ambient concentrations. Despite the dominance of overland flow in the hydrologic regime and the abundance of organic material in the stream channel and floodplain, concentration patterns of the filterable constituents of streamflow during floods in Creeping Swamp are similar to the patterns in streams draining upland watersheds, where contact between runoff waters and the inorganic strata of watershed soils is likely much greater. The concentrations of particulate forms of phosphorus, silicon, and most of the metals studied increased during the rising limb of the hydrograph, peaked prior to peak streamflow, and decreased thereafter. The contribution of floods to total annual flux of P, Fe, Si, and Al in Creeping Swamp is especially great because of large increases in concentrations of the particulate forms of these elements as streamflow increases. (Water quality, stream, flood, swamp).
Water Resour. Res., Paper 80W1742

Particles and Fields—Ionosphere

5545 Ionospheric disturbances
SATELLITE WAKE STRUCTURE OBSERVED BY THE GYRO-PLASMA PROBE INSTALLED ON TAIYO
T. Takahashi (Geophysical Institute, Tohoku University, Sendai, 980 Japan) and H. Oya
Observations of the wake behind a moving obstacle in the ionospheric plasma are made by the impedance probe onboard TAIYO satellite. The wake structure is obtained with high angular resolution in a form of the beat pattern in the obtained electron density due to the difference of the spin period and the sampling period of the data for the observation. The detection of the wake structure was made both from the measured upper hybrid resonance frequency and measured sheath capacity of the probe. The measured wake structures by these two methods show slight difference due to the difference of the pick up area of the information to deduce the electron density. The preliminary analysis of the wake structures for various ionospheric conditions show that these results contain the information on the ionospheric plasma parameters such as the ion temperature, as well as the electron density. We have obtained ion temperatures both for the daytime and nighttime ionospheres, the results are consistent with each case expected for the ionosphere under the daytime or the nighttime conditions. (Satellite wake, gyro-plasma probe).
Sci. Rep. Tohoku Univ., Ser. 5 (Tohoku Geophys Journ.), Vol. 27, Nos. 3/4, 1980

5545 Ionospheric disturbances
THE E- AND F-REGION IONOSPHERIC RESPONSE TO SOLAR FLARES [illegible] SOLAR FLARE EUV FLUXES
J.T. Mariska (Code 4175M, Naval Research Laboratory, Washington, D.C. 20375) and E.S. Oran
SOLRAD and many other satellite systems have provided a large data base showing the time-dependent behavior of broad band solar fluxes in the X-ray and EUV spectral regions. These bands are broad in the sense that one band may contain many ionospherically important spectral lines. We present results of tests performed to determine how this information can best be used to predict the effects of a solar flare on the ionosphere. Our approach has been to first adopt a model of the spectral line and continuum enhancements based on a synthesis of many types of flare observations. This detailed spectral model is used in a time-dependent ionosphere model to calculate the response of the electron and ion density profiles. Then the spectral model is mathematically filtered to show how it would appear to the SOLRAD EUV detectors, and this degraded information is used in the ionosphere model. Comparison of the two ionosphere calculations shows that the two spectra produce changes in the total electron content in the ionosphere that differ by only a few percent. Thus, given the present uncertainty in our knowledge of solar flare EUV spectra, SOLRAD broad band EUV solar flux measurements can be used to calculate the ionospheric effects of EUV flare enhancements. Significant changes due to the flare which occur in the individual species densities are described.
J. Geophys. Res., Blue, Paper 1A0156

5563 Plasma motion, convection, or circulation
ANTI-SOLAR ACCELERATION OF IONOSPHERIC PLASMA ACROSS THE VENUS TERMINATOR
V. Knudsen (Lockheed Palo Alto Research Laboratory, 3251 Hanover Street, Palo Alto, California 94304), K. Spenner and K. Miller
We demonstrate that the horizontal ionospheric particle pressure gradient across the Venus terminator is the principal body force accelerating the plasma to the observed anti-solar velocity. The large scale horizontal $\vec{J} \times \vec{B}$ electromagnetic body force is typically an order of magnitude smaller than the particle pressure gradient. The viscous body forces above 300 km—drag or acceleration—are also an order of magnitude smaller than the pressure gradient body force. In the immediate vicinity of the ionopause where the ionospheric plasma density decreases below 10^4 ions/cm^3 and the magnetic field strength increases, the electromagnetic body force may become significant. The electromagnetic body force may also be significant in the nightside ionosphere. The bulk of the ionospheric flow momentum is not derived from the ionosheath momentum. (Plasma transport, Venus, particle pressure gradient)
Geophys. Res. Lett., Paper 1L0134

5563 Plasma motion, convection or circulation
A THEORETICAL COMPARISON BETWEEN APPARENT AND REAL VERTICAL IONIZATION DRIFT VELOCITIES IN THE EQUATORIAL F-REGION
J.A. Bittencourt (Instituto de Pesquisas Espaciais, Conselho Nacional de Desenvolvimento Científico e Tecnológico, 12200 São José dos Campos, SP, Brasil) and M.A. Abdu.
A theoretical analysis of the time-dependent distribution of ionization in the low-latitude ionosphere is performed using a realistic dynamic computer model of the equatorial F-region, with special interest in the vertical motions of the electron density profile at the magnetic equator. The time-dependence of the F2-peak height, at the magnetic equator, is governed primarily by the electromagnetic $E \times B$ plasma drift velocity. It is shown that, for special time periods during sunset and evening hours, when the height of the F-layer is above a threshold of 300 km, the apparent vertical displacement velocity of the F-layer, inferred from ionosonde measurements, is the same as the vertical $E \times B$ plasma drift velocity, as determined from incoherent backscatter radar measurements in the F-region. (Equatorial ionosphere, vertical drift velocities, ionospheric F-region).
J. Geophys. Res., Blue, Paper 1A0096

Particles and Fields—Magnetosphere

5705 Bow shock waves
COLLISIONLESS SHOCKS AND UPSTREAM WAVES AND PARTICLES: INTRODUCTORY REMARKS
C. F. Kennel (Institute of Geophysics and Planetary Physics, UCLA, Los Angeles, CA 90024)
We discuss some aspects of collisionless shock theory that might be pertinent to the problem of upstream waves and particles. It is hoped that our qualitative remarks may be a useful guide for the general reader as he goes through the detailed papers to come.
J. Geophys. Res., Blue, Paper 80A1802

5720 Interactions between solar wind and magnetosphere
SOLAR WIND ENERGY AND ELECTRIC FIELD TRANSFER TO THE EARTH'S MAGNETOSPHERE VIA MAGNETOPAUSE RECONNECTION
W.D. Gonzalez and A.L.C. Gonzalez (Instituto de Pesquisas Espaciais, INPE, Conselho Nacional de Desenvolvimento Científico e Tecnológico, CNPq, 12200 São José dos Campos, S.P., Brazil)
Some general expressions for the convection and parallel electric fields as well as for the energy transfer, due to magnetopause reconnection, are derived using a nose-reconnection model that takes into account the presence of the clefts. For the case of equal geomagnetic and magnetosheath field amplitudes, the expression for the power dissipated by the convection electric field reduces to the substorm parameter ε widely discussed in the recent literature. This result suggests that magnetopause reconnection is defined at the nose with a tilted reconnection line, but that the convection electric field is related only to the dawn-dusk component of the reconnection electric field, as defined at high latitudes (clefts).
Geophys. Res. Lett., Paper 1L0130

5745 Magnetospheric configuration
GLOBAL SIMULATIONS OF THE THREE-DIMENSIONAL MAGNETOSPHERE
J. N. Leboeuf (Department of Physics, University of California, Los Angeles, California 90024) T. Tajima, C. F. Kennel and J. M. Dawson
Global three-dimensional computer simulations of the magnetosphere using a particle MHD code, reproduce the steady-state Dungey magnetospheric topology in three dimensions. We observe the formation of a compression zone downstream of the neutral tail that is probably bounded by wake shocks. This compression zone changes its cross-section with distance downstream. (Computer simulation, three-dimensional, magnetosphere.)
Geophys. Res. Lett., Paper 1L0125

5755 Plasma instabilities
NONDUCTED COHERENT VLF WAVES AND ASSOCIATED TRIGGERED EMISSIONS OBSERVED ON THE ISEE-1 SATELLITE
T. F. Bell, U. S. Inan, and R. A. Helliwell (all at Radioscience Laboratory, Stanford University, Stanford, California 94305)
The ISEE-1 spacecraft has been an important component of VLF wave-injection experiments for studying interactions between coherent VLF waves and energetic particles. The coherent waves are injected into the magnetosphere by ground-based transmitters such as that at Siple Station, Antarctica (76°W, 84°S geographic, L ~ 4.1), and those of the worldwide Omega navigation network. During the period October 1977–August 1979, the Stanford VLF receiver on ISEE-1 acquired data on approximately 90 separate orbits in the plasmasphere in which the satellite longitude lay within 33° of the magnetic field lines linking the Omega, N.D., transmitter (98°W, 46°N geographic, L ~ 3.5). During 12 passes the nonducted Omega signals at 10.2 kHz were observed to trigger VLF emissions on magnetic shells ranging from L = 1.8–3.8. The emission characteristics often differed significantly from those of emissions triggered by ducted signals and detected at ground stations. In many cases each of the triggered signals consisted of a large array of discrete rising tones whose rate of change of frequency approached 40 kHz/sec, a value much larger than that usually associated with emissions triggered by ducted signals. The emission activity occurred during periods in which signals propagated to the spacecraft on at least two separate ray paths of disparate time delay and with a received signal duration of two to four times that of the transmitted pulses. Typically the emission activity took place only along the paths of longer time delay. Unusual emission activity involving signals from the Siple Station transmitter was also observed on two occasions outside the plasmasphere. Our results indicate that the emission generation process can take place under much more general conditions than previously believed.
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5760 Plasma motion, convection, or circulation
FAST PLASMA FLOWS IN THE TRANSLUNAR MAGNETOTAIL
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Unusual, high-speed, antisunward bursts of plasma have been discovered to persistently occur in the translunar magnetotail. Faster, cooler, and less dense than the plasma flows usually seen in the translunar magnetotail, these bursts suggest that small-scale magnetic merging occurs regularly in the plasma sheet. Calculations which assume that the measured particle energy spectra are flowing hydrogen Maxwellians indicate that the bursts have bulk speeds u = 250 to 700 km/sec, ion temperatures kT = 20 to 100 ev, and ion densities n = 0.001 to 0.01 cm^{-3}. Most bursts occur within one hour of changes in the tail magnetic field that suggest the passage of the Moon near magnetic bubbles. Bursts do not seem to be fundamentally caused by strong solar or geomagnetic activity. Rather, the bursts seem to result from the transfer of magnetic field energy to mantle plasma in the translunar magnetotail. (Plasma, magnetotail, magnetic merging).
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5775 Trapped particles
INFERENCE OF RING CURRENT ION COMPOSITION BY MEANS OF CHARGE EXCHANGE DECAY
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The analysis of data from the Explorer 45 (S^3-A) electrostatic analyzer in the energy range 5 to 30 keV has provided some new results on the ring current ion composition. It has been well established that the storm time ring current has a decay time of several days during which the particle fluxes decrease nearly monotonically. In the past, ring current studies have assumed or stated that hydrogen was the dominant ion in the earth's ring current. By analyzing the measured ion fluxes during the several day storm recovery period and assuming that, beside hydrogen, other ions were present and that the decays were exponential in nature, we were able to establish three separate lifetimes for the ions. These fitted decay lifetimes are in excellent agreement with the expected charge exchange decay lifetimes for H^+, O^+, and He^+ in the energy and L-value range of the data. This inference technique, thus, establishes the presence of measurable and appreciable quantities of oxygen and helium ions as well as protons in the storm-time ring current; we also find indications that He^{++} may also be present under these same conditions. The existence of additional ions is not ruled out by this technique. (Ring current, charge exchange, ions, composition, magnetic storms, Explorer 45, magnetosphere, technique).
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